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A Study of the Fruit Diseases Occurring in a Mid-Western Market

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A STUDY OF THE FRUIT DISEASES OCCURRING IN A MID-WESTERN MARKET[1]

By George W. Fischer

INTRODUCTION

Diseases occurring in a market represent to a fair degree the diseases of fruits and vegetables in the field, since, in the majority of cases, the diseases appearing and developing in the markets are but a delayed expression of infection which occurred in the field. Furthermore, since fruits and vegetables in the markets have been shipped in from various sections of the country as well as from foreign lands, the diseases of these plant products represent not only the phytopathological conditions of the local state or country, but also those of any other part of the world whence they came.

In 1927-28, a survey was made of the vegetable diseases occurring in the Evanston (Illinois) markets.[2] In order to supplement this phytopathological survey of the local markets, a study of the fungi occurring on fruits, together with the diseases produced by them, has been undertaken by the writer.

The responsibility for the presence of diseased fruit in the markets cannot be assigned wholly to producer, neither to transporter, nor to commissioner and retailer; and the absence or paucity of such fruit in a market can result only from the cooperation of these three organizations. That these organizations recently have been cooperating and with success, is evinced by the fact that, during the writer's current investigations, in only a few cases was any disease prevalent to the extent of causing conspicuous loss to the retailer. A large number of diseases were found, but the vast majority were not of conspicuous occurrence. It must be recognized, however, that the present survey has been undertaken only during the fall and winter months (October to April, 1928-29), the months of low temperatures and easy control of diseases from a standpoint of refrigeration. Had the survey included the warmer months, it is indeed probable that quite different results would have been obtained.

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[1] Thesis submitted to Graduate School of Northwestern University for the degree Master of Science, but published at Butler University, where the author is now an instructor.

[2] This survey was undertaken by M. S. Dawson. Results are now pending publication.

METHODS AND MEDIA

In collecting material for study, periodical visits were made to the various local fruit markets, and fruit bearing any signs or symptoms of disease was taken. Fruit as it occurred in the box or crate was inspected, as well as that on display. Fruit discarded by the dealers, because of the presence of disease, naturally proved to be the best source of fruit pathogenes.

The diseased fruit was prepared for study in the usual manner by washing first with 0.1 per cent. aqueous solution of mercuric chloride, and then with sterile distilled water. The fruit was then placed in sterile, moist chambers in a warm location (about 19-20 degrees C.) where further development of the diseases took place. Under these conditions, the pathogenes usually produced the various types of fruiting bodies and spores. Single spore cultures were then made by the spore dilution method, and stock cultures were ultimately made of each pathogene so isolated. In the case of fungi which under these conditions would not sporulate readily, as, for example, those causing diseases of cranberry *(Vaccinium macrocarpon Ait.),* cultures were made by the tissue fragmentation method.

Five different media were used: Blakeslee's agar, corn meal agar, sterilized green beans, cranberry agar, and bread. Of these, Blakeslee's agar proved to be the best. The formula, given by Povah (11), follows:

Dry malt extract	20 grams
Dextrose	20 grams
Peptone	1 gram
Agar-agar	20 grams
Distilled water	1 liter

This seems to be by far the best all-round medium, as the pathogenes grew rapidly on it, and produced not only good vegetative growth but usually spores also. All forms cultured on this medium retained their vitality for at least three months, and some even longer. Indeed, it has been shown by Povah (12) that cultures varying in age from three months to five years may still show vitality and resume growth when hot agar is poured into the tube.

The well-known corn meal agar was prepared by the method described by Shear and Wood (16). The supposed advantage in this medium is the production of perfect stages of Fungi Imperfecti. Mycelial, or vegetative growth, is often extremely scant upon this medium, and in all cases much slower than upon Blakeslee's agar.

Green beans proved to be an excellent medium. They were prepared as follows: One green bean was placed in each of a number of test tubes and to each was added about 5 cc. of distilled water. The tubes were plugged and autoclaved at fifteen pounds pressure for one hour. This medium is inferior to Blakeslee's agar in that it is consumed much more rapidly, and hence cultures must be transferred more often. Sterilized green beans are superior to any other medium used, since, for any particular pathogene, growth was more rapid and spore production more luxuriant.

Cranberry agar was used in an effort to induce sporulation of those cranberry fungi which are apparently sterile on all other media used. Other pathogenes were also cultured on this medium, but the results do not justify its further use. Bread was used for various species of Mucor, since Povah (11) has shown the advantages of its use as a standard medium for the study of all the Mucorales.

With a view toward having some kind of record of the comparative growth of the pathogenes on the various media, a table was prepared to show this comparative growth on the three media which were used most extensively in this work, namely, Blakeslee's agar, corn meal agar, and sterilized green beans. The data so obtained is given in Table I.

INOCULATION METHODS

In many cases it became desirable to inoculate various hosts with certain pathogenes, either for the purpose of proving pathogenicity or studying the development of the pathogenes on their hosts.

All fruit before inoculation was thoroughly washed with 1-1000 solution of mercuric chloride, rinsed with sterile distilled water, and then placed in sterile moist chambers.

Inoculations were made by the wound method, that is, the fruit was stabbed with a spear-point needle (previously sterilized) carrying spores, or mycelium, or both, of the pathogene desired. In cases where pathogenicity was to be proved, checks or controls were kept.

TABLE I. GROWTH OF PATHOGENES ON VARIOUS MEDIA

This table includes only the pathogenes which were cultured on more than one medium. Explanations of abbreviations and symbols follow the table. Accordingly, Phomopsis citri, for example, should be interpreted thus: on Blakelee's agar the mycelium is rather luxuriant, very few pycnidia are produced, but each contains abundant conidia. No perithecia were observed.

PATHOGENE	BLAKESLEE'S AGAR				CORN MEAL AGAR				STERILIZED GREEN BEANS			
	MYC.	PER.	CON.	PYC.	MYC.	PER.	CON.	PYC.	MYC.	PER.	CON.	PYC.
Acanthorynchus vaccinii	G	F	O	O	P	G	O	O	F	G	O	O
Alternaria citri	E	O	P	O					F	O	G	O
Alternaria mali	G	O	E	O	E	O	G	O	F	O	G	O
Botrytis cinerea	G	O	G	O	P	O	O	O	F	O	G	O
Cephalothecium roseum	P	O	E	O	P	O	F	O	P	O	G	O
Colletotrichum gleosporioides	F	O	E	O	P	O	G	O				
Diplodia natalensis	E	O	F	F	P	O	F	G	G	O	G	G
Fusicoccum putrefaciens	G	O	G	F					G	O	E	G
Gleosporium musarum	F	O	G	O	F	O	G	O				
Glomerella cingulata	E	P	P	O	F	P	P	O	G	O	F	O
Glomerella cingulata vaccinii	G	O	G	O					G	O	F	O
Guinardia vaccinii	G	O	P	G	P	O	P	P	G	O	P	G
Monilia sitophila	F	O	E	O	F	O	F	O				
Penicillium expansum	P	O	E	O	P	O	F	O				
Pestalozzia guepini	G	O	E	F	P	O	E	E	P	O	E	E
Phoma mali	G	O	E	G	P	O	E	E	F	O	E	E
Phomopsis citri	G	O	E	P	F	O	G	P	G	O	E	E
Physalospora malorum	G	O	G	F	G	O	G	G	E	O	G	E
Pleospora mali	G	G	G	O	F	G	F	O				
Sclerotinia fruticola	G	O	G	O					F	O	G	O
Sporonema oxycocci	G	O	G	F					F	Q	G	G
Thielaviopsis paradoxa	G	O	E	O	P	O	E	O	E	O	E	O
Trichoderma lignorum	G	O	E	O	P	O	P	O				

Abbreviations—MYC.=vegetative mycelium; PER.=perithecia; CON.=conidia; PYC.=pycnidia.
Symbols—E=luxuriant or abundant; G=good or moderate; F=scant or few; P=poor or very few; O=none.

DISEASES FOUND AND PATHOGENES ISOLATED

The hosts, twenty-two in number, are treated separately and in alphabetical order. In order to avoid repetition of material readily obtainable elsewhere, the diseases and pathogenes will merely be listed according to host, except in cases where more lengthy consideration is justified. The only comprehensive "Check List of Diseases of Economic Plants" is that published by Anderson *et al.* (1) in 1926, and, unfortunately, it is not complete. Reference to this work is frequently made.

1. AMYGDALUS PERSICA L. (PEACH)

Anderson *et al.* (1) list some nine or ten diseases that might be expected to occur. Peaches had almost disappeared from the markets when this survey was made, and consequently the observations on this host are almost negligible. One disease was found.

Sclerotinia fruticola[1] (Wint.) Rehm. Brown Rot—Common and very destructive during this survey.

2. ANANAS SATIVUS SCHULT. (PINEAPPLE)

Thielaviopsis paradoxa (De Seyn) Hoehn. Soft Rot—This disease was common in the markets. According to Link and Gardner (8), so common and destructive is it that in shipments of Cuban pineapples 15-25 per cent. losses due to Thielaviopsis rot are accepted as a matter of course. Cobb, according to Edgerton (4), states that the macroconidia produced by this fungus will germinate only after a period of rest. The writer, however, has germinated freshly formed macroconidia on Blakeslee's agar, where they develop a mycelium rapidly. Prompt germination of microconidia is undisputed.

The cultural characteristics of this fungus are peculiar enough to justify some mention. Within twenty-four hours after inoculation on Blakeslee's agar a distinct odor is produced which is strongly suggestive of stewed apricots. Within another twenty-four hours a stronger and even more pleasant odor is developed. This second odor is probably due to the formation of an ester, probably ethyl-acetate. On the third day, however, all odor is gone, and no odor has ever been noticed subsequent to the third day. The pycnidial stage, mentioned by Patterson *et al.* (10), was not observed.

Trichoderma lignorum (Tode) Harz. Trichoderma Rot—A minor disease, but collected on several occasions.

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[1] The nomenclature of Roberts and Dunegan (15) has been followed.

3. CITRUS AURANTIFOLIA SWINGLE. (LIME)

Diplodia natalensis Ev. Stem-End Rot—Rare during this survey, having been found only once. Although not found on any other citrus host, cross-inoculations to grapefruit, oranges and lemons were very successful; in each case the typical Diplodia stem-end rot was produced. (See Plate V, Fig. 10.) Conidia of *Diplodia natalensis* are shown in Fig. 9, Plate III.

Penicillium digitatum (Fr.) Sacc. Green-Mold Rot—Very common and destructive.

4. CITRUS GRANDIS OSBECK. (GRAPEFRUIT)

Phomopsis citri Fawc. Stem-End Rot—Common and destructive during this survey. Affected fruit placed in moist chambers or artificially inoculated, developed an appearance such as is shown in Fig. 9, Plate V.

Oospora citri-aurantii (Ferraris) Smith. Soft Rot, Sour Rot, Oospora Rot—This disease of citrus fruits was found a number of times during the present survey, and every fruit attacked was rendered not only worthless, but obnoxious, due to the foul odor which usually accompanies the later stages of the disease. The pathogene is illustrated in Figs. 15 and 16, Plate III.

Penicillium digitatum (Fr.) Sacc. Green-Mold Rot—This disease was the cause of more loss to the retailer than any other disease found on grapefruit.

Colletotrichum gleosporioides Pens. *(Glomerella cingulata* (Ston.) Spauld. and Schrenk). Anthracnose, Anthracnose Rot—This is a minor disease, fairly common, but never destructive, as observed during this survey.

5. CITRUS LIMONIA OSBECK. (LEMON)

Penicillium italicum Wehm. Blue-mold rot.

Penicillium digitatum (Fr.) Sacc. Green-Mold Rot—These diseases, as usual, were very common and destructive, and were the source of considerable loss. They were the only diseases found on this host.

6. CITRUS NOBILIS LOUR. (TANGERINE)

Phomopsis citri Fawc. Stem-End Rot—This disease was found on numerous occasions, causing appreciable loss.

Penicillium digitatum (Fr.) Sacc. Green-mold rot.

Penicillium italicum Wehm. Blue-mold rot.

7. CITRUS SINENSIS OSBECK. (ORANGE)

Oospora citri-aurantii Smith. Sour Rot—Of rather common occurrence. Artificial inoculations were very successful; each time the characteristic wrinkled appearance resulted, as shown in Plate IV, Fig. 2.

Alternaria citri Pierce. Black Rot—Black rot was found on numerous occasions on navel oranges, but rarely to the extent that the fruit attacked was rendered unsalable. Bartholomew (3) states that it is as yet undetermined whether or not the fungus causing the Alternaria rot of lemons is the same as that causing the black rot of the navel orange. The writer has successfully cross-inoculated lemons with *Alternaria citri* from navel oranges. The decay so produced was very similar to that described for Alternaria rot of lemons, especially type No. 2 of Fawcett and Lee (6). It seems probable that the black rot of oranges and the Alternaria rot of lemons have the same casual organism. Oranges infected with *Alternaria citri* and placed in a moist chamber soon showed considerable signs of the disease, as illustrated by Figs. 11 and 12, Plate V.

Penicillium digitatum (Fr.) Sacc. Green-mold rot.

Penicillium italicum Wehm. Blue-Mold Rot—These were the most destructive diseases of oranges in the local markets. Local fruit dealers, in saving diseased fruit for the author, would often have ten or a dozen oranges laid away, all affected with blue and green-mold rots.

Fusarium sp. Fusarium Rot—Among the pathogenes isolated from diseased oranges was a Fusarium, belonging to the section Roseum of Sherbakoff (17). The fungus is apparently a weak parasite, since ripe fruit which had remained too long in the markets seemed to be especially suspectible. Turrley (18) reports a Fusarium on grapefruit which produces a rot of very similar behavior. Sound oranges inoculated with this Fusarium developed the characteristic, slow-developing, tough, brown rot illustrated in Fig. 7, Plate V.

Colletotrichum gleosporioides Penz. Anthracnose Rot—As with grapefruit, this disease is only a minor one, due to the fact that it develops so slowly, and attacks, chiefly, over-ripe fruit.

8. CUCUMIS MELO L. (CANTELOUPE, MELON, ETC.)

This host includes such melons as honey dew, Persian melon, canteloupe, muskmelon, etc. Two of the six pathogenes isolated from these melons are probably heretofore unreported.

Alternaria sp. Alternaria Fruit Spot—This was by far the most conspicuous pathogene isolated from melons during this survey. The fungus appears to belong to Elliot's (5) *Alternaria brassicae* var. *microspora* group. The disease is evident as soft, discolored spots, often with white or gray mycelium on the surface (Plate V. Fig. 8).

On Blakeslee's agar the fungus is mouse-gray (Ridgway, 13) above and black beneath. Conidia from agar cultures are ovate, obovate or short clavate, often verrucose, dark brown, transversely 1-3 septate, and occasionally with one longitudinal septum. The size is variable, ranging 10.5-17.5 x 5.5-10.5 microns, but averaging 12-16 x 7-10.5 microns.

Monilia sitophila (Mount) Sev. Soft Rot—This fungus has not previously been reported as parasitic on melons, yet the writer has collected it from both cassaba and honey dews, and, by artificial inoculations, established its pathogenicity on these hosts. It produces a soft rot, developing with fair rapidity. The affected areas, especially in a moist chamber, become covered with a beautiful fluffy, salmon-orange (Ridgeway, 13) mass of mycelium and spores. When inoculated into healthy honey dew melons, the fungus produces a decay like that described above.

Rhizopus nigricans Ehrenb. Watery Rot—Not common, but rapid in development and consequently destructive.

Cephalothecium roseum Corda. Pink-Mold Rot—Although this fungus has not previously been reported as pathogenic on honey dews, it has twice been found on these by the author. The rot produced is not rapid and is only a minor disease. It is evident as a small, rather dry, softened area, over which is the characteristic pink covering of conidia and conidiophores. When inoculated into a sound honey dew, the fungus produced a slow, dry decay which soon became covered with pink tufts of conidia and conidiophores.

Fusarium sp. Fusarium Rot—A species of Fusarium belonging to the section Martiella of Sherbakoff (17). The disease produced is a soft decay, over which is developed a mycelium and spores. Blakeslee's agar is turned morocco red (Ridgway, 13) by the fungus. On this medium there is a white surface mycelium. Here and there are produced olive-buff (Ridgway, 13) masses of macroconidia. In old cultures one or more cells of these spores may develop into echinulate chlamydospores. These are mostly terminal (but often intercalary), globose, echinulate, light-brown, and measure 6-12 microns. Microconidia are elliptical, minute, continuous, and measure 4-8 x 2-3 microns. Conidia and chlamydospores are shown in Fig. 13, Plate III.

9. CYDONIA OBLONGA MILL. (QUINCE)

Most of the quinces in the local market had some blemishes or disease. In fact, it took considerable inspection to obtain disease-free fruit for inoculation. Of the eight pathogenes isolated from quinces, one *Botrytis cinerea* Pers. has not previously been reported for this host.

Sclerotinia fruticola (Wint.) Rehm. Brown Rot—Brown rot was, without doubt, the most common and destructive of the quince diseases found in the local markets during the past fall and winter.

Penicillium expansum (Link) Thom. Blue-Mold Rot—Common but not as destructive as brown rot.

Fabraea maculata (Lev.) Atk. Black Spot—This disease was by far the most common of those found on the quince. Scarcely a single quince was absolutely free from the disease and most were conspicuously spotted with it. However, the disease is, at most, only a conspicuous external blemish, since the fruit is not affected internally.

Glomerella cingulata (Ston.) Spauld. and Schrenk. Bitter Rot—Bitter rot was not as common on quince as on other hosts studied, and appeared to cause comparatively little damage.

Phoma mali Schulz and Sacc. Fruit Rot—Common but not as destructive as some other quince pathogenes, since the rotted areas seldom attain any great size.

Botrytis cinerea Pers. Gray-Mold Rot—This fungus has apparently not been previously reported as causing a disease of quince fruits. Certain diseased quinces collected during the fall of 1928 developed, in a moist chamber, a rapid, soft, brown rot, which became covered with the grayish-brown mycelium and spores of *Botrytis cinerea.*

That this fungus is distinctly pathogenic on this host was decidedly proved by inoculation experiments. Within forty-eight hours distinct circular decay had started. At the end of five days the rotted area had increased to approximately 30 millimeters in diameter. The decay was not confined to surface tissue, but very early penetrated deeply into the fruit inoculated. The rot soon enveloped the entire fruit, after which the above-described conidial production followed. Figs. 5 and 6 (Plate IV) show a quince five and thirty days, respectively, after inoculation. (Fig. 6 is not the same quince as shown in Fig. 5.)

Cephalothecium roseum Corda. Pink-Mold Rot—This pathogene was commonly found around black-spot lesions (caused by *Fabraea maculata)* and occasionally had enlarged these areas. Otherwise the destruction caused by this fungus was almost negligible.

Alternaria mali Roberts. Alternaria Rot—Alternaria rot was of frequent occurrence on quinces during the autumn of this survey. An excellent account of the casual organism, *Alternaria mali,* is given by Roberts (14).

10. DIOSPYROS KAKI L. (JAPANESE PERSIMMON)

Botrytis cinerea Pers. Gray-Mold Rot—Collected only once. This disease is apparently uncommon.

Penicillium expansum (Link) Thom. Blue-Mold Rot—This common pomaceous fruit parasite was isolated a few times from persimmons, but was not observed to be as destructive as on quinces or apples.

Alternaria sp. Black Rot—In addition to the two pathogenes described above, a species of Alternaria was also isolated. This fungus has distinctly muriform spores, and belongs to Elliot's (5) *Alternaria tenuis* group.

11. FORTUNELLA MARQUARITA SWINGLE. (OVAL KUMQUAT)

Phomopsis citri Fawc. Stem-End Rot—This disease was very prevalent and destructive on kumquats in the local markets. Nearly every basket of the fruit had at least one which was noticeably affected with the disease. It is evident as a very soft, watery decay, usually at the stem end, although this was not always the case.

Alternaria citri Pierce. Black Rot—One kumquat collected was affected with a dark decay, more internal than external. The pathogene was obtained by transfers of diseased tissue to Blakeslee's agar. The fungus resembles *Alternaria citri* in every way, and, in the opinion of the author, is identical with it. Future observations will determine the importance of this disease of kumquats.

12. FRAGARIA SPP. (STRAWBERRY)

Anderson *et al.* (1) list eight fruit-rotting organisms of the strawberry. Only two of these were found by the writer, however. They were the two most destructive in storage and transit.

Botrytis cinerea Pers. Gray-mold rot.

Rhizopus nigricans Eherenb. Leak—These two diseases were fairly common on strawberries in the local markets, although the latter was not found until the reappearance of strawberries late in February, when it was commonly found.

13. MALUS SYLVESTRIS MILL. (APPLE)

Of the ten pathogenes isolated from various varieties of apples, only one, *Penicillium expansum,* was conspicuously common. In fact, the apple scab fungus, *Venturia inequalis* (Cke.) Anderh., conceded by most authorities to be the most important pathogene of the apple, was found only once. The answer presents itself immediately. Apple scab is almost entirely a disease of the field, and cannot be expected to be found on the ultra-fancy apples, from well-sprayed trees, such as now grace the markets.

Penicillium expansum (Link) Thom. Blue-Mold Rot—This disease was found on every variety of apple in the markets, and was the source of more loss to the retailer than all the other diseases of this host combined.

Rhizopus nigricans Ehr. Rhizopus rot collected once during the entire survey.

Physalospora malorum (Pk.) Shear. Black Rot—Jonathan, Grimes Golden, Rome Beauty, Yellow Ortley and Spitzenburg were the varieties which were found affected with this disease, which was often found but not to the extent of causing any severe loss. Apples inoculated and left undisturbed were eventually reduced to mummies as shown in Plate IV, Fig. 4. *Physalospora malorum* is illustrated in Figs. 7 and 8, Plate III.

Alternaria mali Roberts. Alternaria Rot—This disease was found a sufficient number of times to indicate that it is an important disease of apples in storage and transit. It was found more frequently on Rome Beauty, Jonathan and Greening than on any other varieties. The decay usually penetrated deep into the apple, as shown in Plate IV, Fig. 3. The fungus is illustrated in Figs. 11 and 12, Plate III.

Mucor griseo-lilacinus Povah. Mucor Rot—Diseased tissue transfers, of a rotted apple collected on one occasion from apples of the Greening variety, to Blakeslee's agar, yielded in every case an interesting species of Mucor, which proved to be *M. griseo-lilacinus.* The fungus produces a rapid, soft, brown rot.

Botrytis cinerea Pers. Gray-Mold Rot—Collected on only one occasion, gray-mold rot of apple seems to be of little importance.

Venturia inequalis (Cke.) Aderh. Scab—This disease was found on one occasion in a basket of poor quality Russets, of which many of the fruit were affected.

Glomerella cingulata (Ston.) Spauld. and Schrenk. Bitter Rot—Bitter rot was collected several times, but the disease was not observed to be in any measure serious.

Pleospora mali Newton. Pleospora Rot—This disease, newly discovered, and its causal organism recently described by Newton (19), was found on one occasion on some apples of undetermined variety. The rotted areas closely resembled those produced by *Alternaria mali*.

Phoma mali Schulz and Sacc. Phoma Rot—This fungus was isolated from rather dry brown, rotted spots on apples, and was first obtained in culture by transferring bits of diseased tissue to Blakeslee's agar. Later, apples were found which had somewhat larger rotted areas, scattered over which were numerous small pycnidia. Fig. 1, Plate IV, shows the result of inoculation of an apple with *Phoma mali*. Conidia are shown in Fig. 4, Plate III. The rot develops comparatively slowly, and is consequently of less economic importance than some other apple rots.

14. MALUS SPP. (CRAB APPLE)

Penicillium expansum (Link) Thom. Blue-Mold Rot—Common on crab apples during this survey.

Physalospora malorum (Pk.) Shear. Black Rot—On only two occasions were crab apples collected which were affected with this disease.

Phoma mali Schulz and Sacc. Phoma Rot—Rare on the markets during current investigations.

Glomerella cingulata (Ston.) Spauld. and Schrenk. Bitter Rot—Also uncommon, being found only twice.

15. MUSA SAPIENTUM LINN. (BANANA)

Only one disease was found on this host—the common ripe rot or anthracnose.

Gleosporium musarum Cke. and Mass. Ripe Rot—So common was this disease that practically any banana from the local markets became entirely rotted by it if placed in a moist chamber. However, since the disease involves little or no more than the peel of the banana, and since it is associated with the normal ripening of the fruit, it does not cause fruit so affected to be discriminated against by the consumer. *Gleosporium musareum* is illustrated in Figs. 5 and 6, Plate III.

16. OPUNTIA TUNA MILL. (PRICKLY PEAR)

This fruit is not common on the markets and consequently has been neglected by practically all who have engaged in fruit disease work. The author has found only one pathogene on the prickly pear.

Penicillium expansum (Link) Thom. Blue-Mold Rot—This common parasite of pomaceous fruits was observed to produce a soft, watery, light-brown rot of the prickly pear fruit. Not long after the diseased fruit was placed in a moist chamber, the rotted area became covered with blue-green tufts of conidiophores and conidia. The disease was found only a few times.

17. PERSEA AMERICANA MILL. (AVOCADO PEAR, ALLIGATOR PEAR)

Glomerella cingulata (Ston.) Spauld. and Schrenk. *(Colletotrichum gleosporioides* Penz.) Anthracnose Rot—Many avocados were found in the local markets which were more or less severely affected with anthracnose. The disease was evident as a dark-brown, soft rot, sometimes so covered with conidia as to present a shiny brownish pink appearance to the rotted area, which was sometimes quite large.

Pestalozzia guepini Desm. Fruit Spot—This disease was found once on avocado, where it was producing large dirty-white spots with considerable rotted tissue beneath. More or less imbedded in the mycelium of these spots were numerous acervuli of the causal organism. The conidia are illustrated in Fig. 3, Plate III.

Horne (7) also reports a *Pestalozzia* sp. on avocado, but does not assign it to any described species.

18. PRUNUS SPP. (PLUM)

Sclerotinia fruticola (Wint.) Rehm. Brown Rot—Common and very destructive during the short time this fruit was on the market.

Penicillium expansum (Link) Thom. Blue-Mold Rot—Not as common and destructive as brown rot, but was the source of appreciable loss. Infection was nearly always at the stem end.

19. PUNICA GRANATUM L. (POMEGRANATE)

Botrytis cinerea Pers. Gray-Mold Rot—Gray-mold rot is rather slow-developing on this host and hence is not destructive. It was found several times.

Penicillium expansum (Link) Thom. Blue-Mold Rot—Less common but more destructive than the gray-mold rot.

20. PYRUS COMMUNIS L. (PEAR)

Penicillium expansum (Link) Thom. Blue-mold Rot—Of the six pathogenes isolated from pear, blue-mold rot was by far the most common and destructive, and was the source of considerable loss to local fruit dealers.

Sclerotinia fruticola (Wint.) Rehm. Brown Rot—Brown rot of the pear was found only once, and on a collection of the Kiefer variety.

Rhizopus nigricans Ehr. Black-Mold Rot—Found a few times on a few of the softer, fancier varieties.

Glomerella cingulata (Ston.) Spauld. and Schrenk. Bitter Rot—Uncommon during the present survey.

Fabraea maculata (Lev.) Atk. Black Spot—Common on pears during the fall and early winter of 1928, but was not nearly as serious as the same disease on quince, inasmuch as the spots were much smaller and less conspicuous.

Botrytis cinerea Pers. Gray-Mold Rot—Not common.

21. VACCINIUM MACROCARPON AIT. (CRANBERRY)

Ten pathogenes were isolated from this host, three of which were not identified, due to the absence of spores on Blakeslee's, corn meal, or cranberry agar, or on sterilized green beans.

Acanthorynchus vaccinii Shear. Blotch Rot—Approximately 10 per cent. of the cranberry fungi cultures yielded *Acanthorynchus vaccinii.*

Glomerella cingulata vaccinii Shear. Anthracnose, Bitter Rot—Bitter rot was as prevalent on cranberries in the local markets as was the blotch rot. Berries so affected had a dry, tough rot, chiefly on the sides. Conidia illustrated in Fig. 2, Plate III.

Guignardia vaccinii Shear. Early Rot—Early rot was uncommon in the local markets during this survey. The fungus was almost entirely sterile on all the media used except cranberry agar. Pycnidia were formed in abundance on the other media, but were nearly all sterile, while on cranberry agar, every pycnidium examined contained numerous conidia.

Fusicoccum putrefaciens Shear. [1]End Rot—This is usually cited as the most destructive of the many cranberry diseases in the United States. From 750 cultures which Bain (2) made from cranberries rotted in storage, 63 per cent. developed *Fusicoccum putrefaciens.* The author, however, obtained this fungus only once from cultures from over eighty diseased cranberries known to have come from various cranberry-producing regions. *Fusicoccum putrefaciens* is illustrated in Figs. 10 and 14, Plate III.

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[1] Now shown to be *Godronia Cassandrae* by Shear, Phytopath. 19: 1017-1024. 1929.

Sporonema oxycocci Shear. Ripe Rot—Ripe rot, while sometimes important, has not been found by other investigators to cause destruction to the extent caused by the cranberry fungi described above. It is possible that this year the disease was more prevalent than usual, for of the author's cranberry cultures, 8 per cent. yielded the ripe rot organism. The organism is illustrated in Fig. 1, Plate III.

Botrytis cinerea Pers. Gray-Mold Rot—Only one diseased cranberry yielded cultures of *Botrytis cinerea,* showing that, as usual, this disease is of uncommon occurrence.

Penicillium spp. Soft Rot—Two or three undetermined species of Penicillium were also isolated from diseased cranberries. These are evidently of some importance, since approximately 15 per cent. of the author's cranberry cultures yielded species of Penicillium. Bain (2) reports 13 per cent. for only one undetermined species of this genus.

None of the above-listed cranberry fungi represent the most common fungus obtained from diseased cranberries. Approximately 30 per cent. of all diseased cranberries studied yielded a dark-gray, luxuriantly-growing fungus which is possibly *Helminthosporium inaequalis* Shear, but since none of the cultures of this fungus have yet produced spores, its identity is uncertain.

22. VITIS SPP. (GRAPE)

One of the four pathogenes isolated has not previously been reported as parasitic on this host.

Botrytis cinerea Pers. Gray-Mold Rot—Isolated from two collections of diseased grapes from local markets.

Mucor heimalis Wehm. Mucor Rot—Diseased tissue transfers of some diseased grapes, softened and shriveled, of the Rabier variety, yielded in every case a species of Mucor, which was later identified as *M. heimalis.*

Alternaria mali Roberts. Alternaria Rot—Fragmentation cultures of a collection of rotted Malaga grapes yielded only one pathogene, a species of Alternaria, which was later identified as *A. mali.* The fungus so nearly agrees with *Alternaria mali,* both macro- and microscopically, that, in the opinion of the writer, it is identical with it. Grapes, when inoculated, developed a soft brown rot in a few days, which advanced rapidly until a diameter averaging 10-15 mm. had been reached, after which the progress was very slow. This fungus is well known as a parasite of apple leaves and fruit, but apparently has never been reported as a parasite of grapes.

Penicillium spp. Penicillium Rot—Two or three species of Penicillium have also been isolated from decaying grapes. Penicillium rots of grapes are quite common in the markets, where they cause, perhaps, greater loss than any other pathogene on this host.

The writer wishes to acknowledge his indebtedness for innumerable valuable suggestions and ever-ready assistance to Professor A. H. W. Povah, under whose supervision this survey was made, and also to Professor W. G. Waterman for instruction in photography.

SUMMARY

1. Of the twenty-two different kinds of fruits on the markets in Evanston, from October, 1928, to March, 1929, inclusive, none were disease-free, and from some as many as eight to ten pathogenes were isolated.
2. Over eighty diseases were found on fruits in the Evanston markets during this survey.
3. The fungi causing these diseases represent twenty-seven genera and thirty-five species, all but two[1] of which were isolated in pure culture and studied on various media.
4. Four hosts are reported for the first time as follows:
5. *Botrytis cinerea* is established as an active parasite on the quince fruit, producing a rapid, soft, brown rot.
6. *Monilia sitophila* produces a soft, transparent decay on the honey dew and cassaba melons.
7. Honey dew melon is subject to a soft, relatively dry decay, produced by *Cephalothecium roseum.*
8. *Alternaria mali* is reported for the first time as a pathogene of grapes, causing a soft, brown decay.

[1] *Fabraea maculata* and *Venturia inaequalis,* whose conidia could not be induced to germinate.

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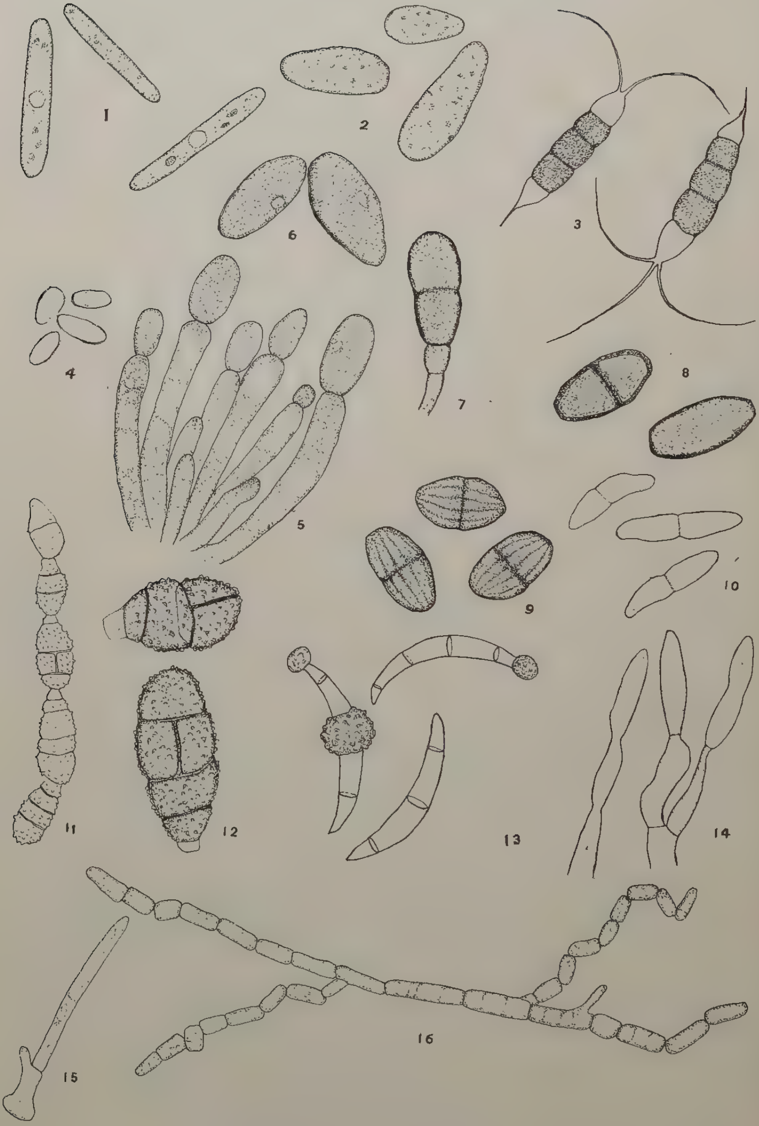
PLATE III



EXPLANATION OF PLATES

All drawings were made with the aid of the camera lucida. Except where otherwise stated, the fruits illustrated in Plates IV and V were artificially inoculated.

PLATE III

Fig. 1. Mature conidia of *Sporonema oxycocci;* x 1150.
Fig. 2. Mature conidia of *Glomerella cingulata* var. *vaccinii;* x 1000.
Fig. 3. Mature conidia of *Pestalozzia guepini;* x 1000.
Fig. 4. Mature conidia of *Phoma mali;* x 1000.
Fig. 5. *Gleosporium musarum;* cluster of conidiophores and conidia in various stages of development; x 1000.
Fig. 6. Mature conidia of *Gleosporium musarum;* x 1000.
Fig. 7. Single conidiophore and conidium of *Physalospora malorum;* x 1000.
Fig. 8. Septate and nonseptate conidium of *Physalospora malorum;* x 1000.
Fig. 9. Mature conidia of *Diplodia natalensis,* showing striations on the exospore; x 1000.
Fig. 10. Mature conidia of *Fusicoccum putrefaciens;* x 1000.
Fig. 11. Single chain of conidia of *Alternaria mali;* x 250.
Fig. 12. Single conidia of *Alternaria mali,* showing the verrucosity typical of mature conidia; x 725.
Fig. 13. Conidia from an old agar culture of *Fusarium* sp. Section Martiella (Sherbakoff, 17), isolated from honey dews. Note how some of the cells develop into echinulate chlamydospores; x 650.
Fig. 14. *Fusicoccum putrefaciens,* simple and branched conidiophores with conidia; x 1000.
Fig. 15. *Oospora citri-aurantii;* germinating spore eighteen hours after being sown on Blakeslee's agar; x 1000.
Fig. 16. *Oospora citri-aurantii;* germinating spore twenty-four hours after being sown on Blakeslee's agar, showing how the hyphae break up into conidia; x 1000.

PLATE IV

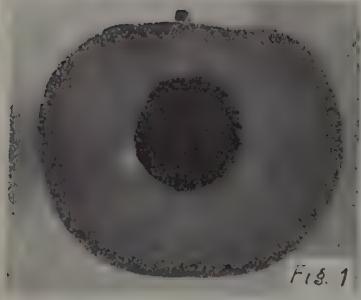


Fig. 1

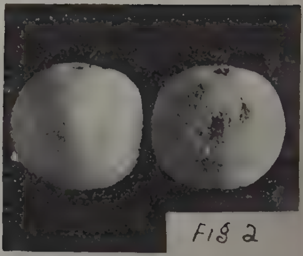


Fig 2

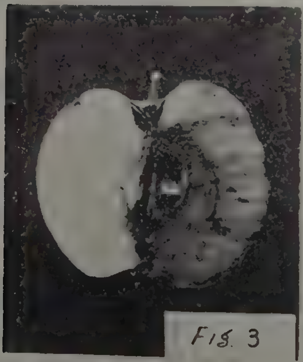
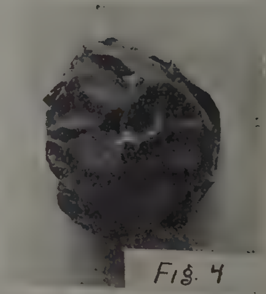


Fig. 3



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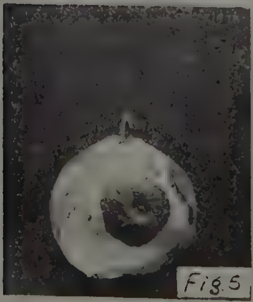

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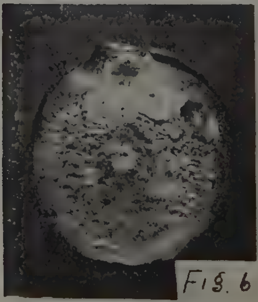


Fig. 6

PLATE IV

Fig. 1. Apple, two weeks after inoculation with *Phoma mali,* showing concentric growth of the rotted area.

Fig. 2. On the right, an orange two weeks after being inoculated with *Oospora citri-aurantii,* showing the wrinkled appearance of the rotted area. On the left is the control.

Fig. 3. Vertical section of an apple, half of which had been rotted by *Alternaria mali.*

Fig. 4. Grimes Golden apple one month after inoculation with *Physalospora malorum,* showing the mummified condition which results.

Fig. 5. Quince five days after being inoculated with *Botrytis cinerea,* showing the lesion produced.

Fig. 6. Quince thirty days after inoculation with *Botrytis cinerea,* showing the thoroughly rotted condition and the spore-production on the surface.

PLATE V

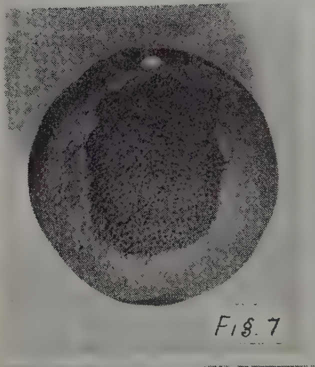


Fig. 7

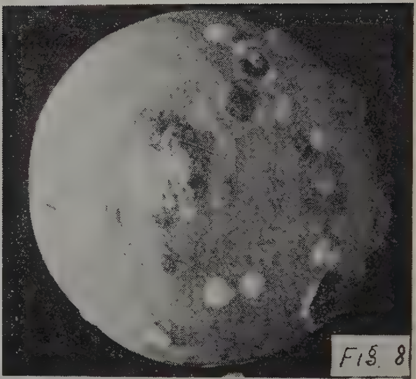


Fig. 8

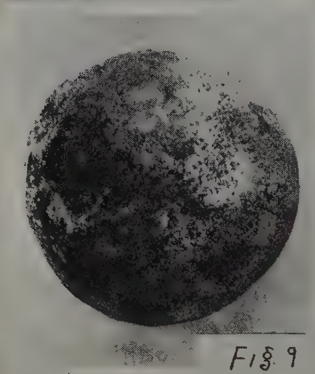


Fig. 9

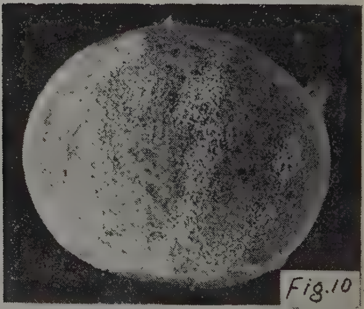


Fig. 10

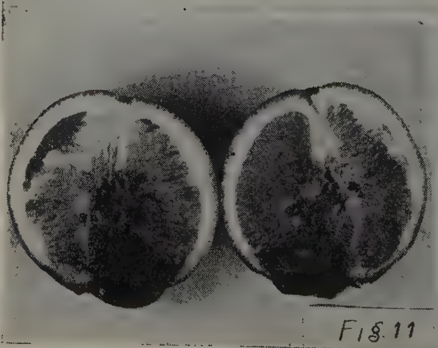


Fig. 11

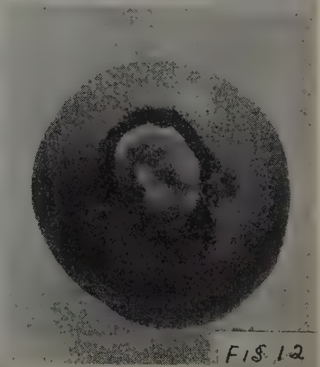


Fig. 12

PLATE V

Fig. 7. Orange three weeks after inoculation with *Fusarium* sp., showing the brown, leathery rot produced.

Fig. 8. Honey dew melon naturally affected with Alternaria fruit spot (*Alternaria* sp.).

Fig. 9. Grapefruit three weeks after inoculation with *Phomopsis citri,* showing the numerous white pycnidia on the surface.

Fig. 10. Grapefruit ten days after inoculation with *Diplodia natalensis,* showing the growth of the fungus in longitudinal ridges corresponding to the divisions in the grapefruit.

Fig. 11. Same as Fig. 12, but cut longitudinally to show the extent of the black rot in the interior.

Fig. 12. Same orange as in Fig. 11, before being cut longitudinally. This was a market specimen of black rot of the navel orange, caused by *Alternaria citri.*

CERTAIN FLORISTIC AFFINITIES OF THE TREES AND SHRUBS OF THE GREAT SMOKY MOUNTAINS AND VICINITY

By STANLEY A. CAIN

It is widely admitted that the forests of eastern United States reach their culmination in the southern Appalachians, particularly in the Unaka range of North Carolina and Tennessee. It is in the mountains of this range that the greatest height east of the Rocky mountains is reached; in the Black mountains with Mt. Mitchell, the Craggy mountains and the Great Smoky mountains, with some forty peaks over 6,000 feet in altitude, and with Mt. Guyot and Clingman's Dome topping them all. Here on these lofty peaks (for many of them rise over a mile in altitude above their base), in a region of high rainfall and high humidity, there is a rich flora—rich in species and rich in numbers.

The arborescent flora of these mountains is essentially composed of a forest of deciduous broad-leaf trees which surround the island-like areas of coniferous vegetation on the higher mountain summits. These coniferous forests are distinctly northern in their affinities, but in the minds of the laity are associated with the country where they are found. Historically, in all likelihood, the trees of the northern forest, north of the great terminal moraine, have been derived from farther south, and, in all probability, from the higher Appalachian ranges, especially those here under consideration.

SOUTHEASTERN UNITED STATES AS A CENTER OF GEOGRAPHICAL DISTRIBUTION

Harshberger (4), in his Phytogeographic Survey, says: "The deciduous forest of eastern North America has been derived from that forest which reaches its greatest development in the mountainous region of western North Carolina and eastern Tennessee. . . . In eastern North America a large number of species came from the great mixed forest in which broad-leaved trees and conifers were intermixed. The latter were found especially, perhaps, during glacial times on the mountain tops which had remained undisturbed in their original home. At the close of the long ice age these trees were in a plastic condition through the influence of the pressure of species and through the action of the physiographic vicissitudes to which these forms were subjected."

Sargent (7) shows in a number of valuable maps the geographic distribution of species of many important genera of trees. The geographic distribution proceeded from a territory which seems to center in the area of the present states of southern and central Pennsylvania, Maryland, West Virginia, Kentucky, Tennessee, western North Carolina, southwestern Virginia, northern Georgia, Alabama and Mississippi. A study of these maps reveals an important fact, *viz.,* that the spread of species from this common center has been in more or less concentric waves. Approximately, the trees invaded the northern part of the continent in the order indicated by their present relative position (distribution). Those farthest north entered the glaciated territory first and those farthest south advanced much more slowly. These maps show the outer confines on any particular genus is usually occupied by a single species, nearer the center two species are found, still nearer three, four and more species, if the genus is a large one.

Adams (1) takes this problem up in detail and presents evidence from many writers that Northern states and Middle-Western states show striking affinities with Southeastern states. He says: "Two post-glacial centers of dispersal have been located in the southern part of the United States. The eastern center has been located with Chattanooga, Tennessee, as the approximate center of dispersal or adaptive radiation."

From this center there have been three primary outlets or "highways" of dispersal from the southeast: (1) The Mississippi valley and valleys of tributary streams have been one very important highway—the Tennessee river playing a very important part. (2) The coastal plain, leading along the Atlantic seaboard northward and along the Gulf coast southward and southwest, is a second highway, and probably of least importance. (3) The southern Appalachians and adjacent plateaus formed an outlet to the north—probably the most important of the three.

The role of the Mississippi system in bringing woody flora to states on the upper reaches has been recognized by McMillan for Minnesota, Bessey for Nebraska, Masson for Kansas, Walker for Michigan and Coulter for Indiana. The present writer has observed that Indiana has a closer arboreal affinity with Tennessee than any other state, notwithstanding that the bordering states, Kentucky, Ohio and Michigan, are naturally timbered, *i. e.*, that Indiana and Tennessee have more woody species in common than Indiana has with any other state.

BASIS OF CLASSIFICATION

In the preparation of this floristic study of the woody plants of East Tennessee, it was thought desirable to find a natural basis for the classification. In this connection a number of classifications were reviewed in hope that one would be suitable for the present purpose.

Consideration was given the classification of Merriam (6), which is based on temperature relations. Merriam divided the continent of North America, according to the distribution of plants and animals, into three primary transcontinental zones, called "regions," which in turn were subdivided further. The outline of his classification is as follows:

- Boreal Region
  - Arctic-Alpine zone
  - Hudsonian zone
  - Canadian zone

- Austral Region
  - Transition zone
    - Alleghanian area
  - Upper Austral zone
    - Carolinian area
    - Austroriparian area
    - Semitropical Gulf strip area

There are other divisions, of course, but they are not related to the Tennessee problem and are not considered here.

The Arctic-Alpine zone, which lies above the limit of tree growth, is not represented climatically in the Unaka range of East Tennessee. The next zone, the Hudsonian, comprises the northern part of the great transcontinental coniferous forest and is represented in the southern Appalachians by the spruce-fir forest. The Canadian zone comprises the southern parts of the great transcontinental coniferous forest in Canada and that part of it which lies in the northeastern United States. This zone is represented in the Green mountains, Adirondacks and Catskills, and also in the higher stretches of the mountains of North Carolina and Tennessee. The other zones, except the Semitropical or Gulf strip, which is not represented in Tennessee, that is, the Transition, Alleghanian, Carolinian and Austroriparian, are found in East Tennessee in the foothills and lowlands.

Although these zones of Merriam suffer some telescoping in the Smoky mountains, they are of considerable general significance. However, on examination of the geographical ranges of the species under consideration, it was found that they did not lend themselves geographically to Merriam's life-zone classification. This is due, in part at least, to the following complications: (a) their ranges are not sufficiently accurately described in the manuals, possibly not well enough known; (b) their habitat and site preferences also are not sufficiently well enough known to permit interpretation on that basis; and (c) very large numbers of species spread over more than one life-zone, indicating that such a classification is not always successful.

Study was made of the vegetation zones described by Zon (8). For the eastern forests Zon recognizes seven principal divisions which correspond in the main to the climatic climax types. His groups are as follows:

- Spruce-fir (northern coniferous forest)
- White-Norway-jack pine forest (northeastern)
- Birch-beech-maple-hemlock (northeastern)
- Oak (southern hardwood forest)
  - Chestnut-chestnut oak-yellow poplar
  - Oak-hickory
  - Oak-pine
- Cypress-tupelo-red gum (southern)
- Longleaf-loblolly-slash pine (southeastern)
- Mangrove (subtropical)

The distribution of these forests in the state is as follows: Spruce-fir is on the highest summits of the Great Smoky mountains in the eastern part of the state. The birch-beech-maple-hemlock, or northern hardwood forest, is also in the eastern part of the state immediately below the spruce-fir on the higher slopes. Practically the whole of the state is occupied by the chestnut-chestnut oak-yellow poplar, while the oak-pine type enters the eastern part of the state from the south near Chattanooga, and is characteristic of the sand plains of Middle Tennessee. The cypress-tupelo-red gum type is in the western part of the state but is not found in East Tennessee. Within the state the classification of species fits fairly well with these forest types, but, as in the case of Merriam's classification, it is impossible to arrange many of the species by the areas listed. There is too much overlapping, telescoping, etc.

Next are the phytogeographic regions of Harshberger (4) for the eastern part of the continent:

- I. Arctic and Subarctic zones
    - 1. Arctic region of Labrador, Mackenzie and Arctic shore
    - 2. Subarctic forest region of North Canada and Alaska
        - A. Labrador district
        - B. Hudson Bay district
        - C. Mackenzie district
        - D. Alaska district

- II. North American temperate zone: Atlantic section
    - 1. St. Lawrence-Great Lakes region
        - A. Maritime district
            - a. New Brunswick area
            - b. New England area
        - B. Lake district
            - a. Interlacustrine area
            - b. Adirondack area
    - 2. Atlantic-Gulf coastal region
        - A. Northern Pine Barren-Strand district
        - B. Carolinian Pine Barren-Strand district
        - C. Gulf Pine Barren-Strand district
        - D. Arkansas-Louisiana district
    - 3. Piedmont-Appalachian-Ozark plateau region
        - A. Piedmont district
            - a. Northern area
            - b. Southern area
        - B. Appalachian district
            - a. Northern mountain area
            - b. Southern mountain area
        - C. Alleghanian-Ozark district
            - a. Lacustrine area
            - b. Kentucky-Tennessee area
            - c. Ozark area

The writer is of the conviction that the ideal treatment of the flora of East Tennessee would be one that would show the affinities of that flora with the various regions outlined above, or better, perhaps, some modification of it. These zones are both floristic and physiographic. It is not to be expected, however, that species would abide strictly by such limits. Some zones coincide with the limits of distribution of certain species, but more frequently a zone is characterized by a certain admixture of species in certain abundance, while the same species are to be found in other areas, perhaps in different abundance. After all, the most natural floristic treatment would be one that relates the distribution of species to physiographic provinces similar to those of Harshberger.

It was finally decided that the only practical classification at the present was one essentially geographic in nature, with special reference to the local physiographic areas occupied by the species in the region under consideration. This type of treatment is suggested by Cowles (2), and is followed as closely as the present situation and material will permit.

INTRANEOUS
- Eastern North America (essentially the whole of humid, temperate North America)
- Southeastern United States
- Southern Appalachian
- Endemic (essentially restricted to the Unaka and related mountain ranges)

EXTRANEOUS
- Northeastern United States
- Southeastern Canada
- Canadian Transcontinental
- Southern
- Southwestern

Those species which come under the head "Intraneous" are not, in East Tennessee, near the limits of their distribution, and are wholly indigenous. Those of the first two subgroups are wide-ranging geographically and, apparently, also in their tolerance for soils, climatic conditions, etc. The two categories remaining in the intraneous divisions are essentially similar, the southern Appalachian species being of wider range than those considered as "endemic."

Of the "Extraneous" forms (those species which are, in East Tennessee, at the limits of their distribution), the first three categories are northern, while the other two are southern. The northern species owe their presence in Tennessee to the Appalachian mountains, which provide climatic conditions duplicating those found in their main ranges, sometimes hundreds of miles farther north. The three categories are formed on the extent of their northern range, *i. e.*, those with their main distribution in northeastern United States; those extending into southern Canada; and lastly those which, in Canada, extend across the continent. Of the latter species, some are circumpolar, extending into northern Europe and Asia, others of them find southern extension in the mountains of the West, similar to that here described for the Eastern mountains.

The following classification of woody species would have been very incomplete without the use by the writer of a list of woody plants of East Tennessee prepared by Galyon (3). The writer has collected many and observed some 75 per cent of the species here considered. Miss Galyon's check list is completely backed by herbarium specimens deposited at the University of Tennessee, Knoxville, Tennessee.

The nomenclature follows Gray's Manual, 7th edition, as far as possible; for the remainder Small's Manual is used. An asterisk before the name of a species indicates its addition to Miss Galyon's check list by the writer. The geographic ranges are, in the main, from manual descriptions.

INTRANEOUS

I A. EASTERN NORTH AMERICA (Essentially the whole of humid, temperate North America)

Acer negundo L.
A. nigrum Michx.
A. rubrum L.
A. saccharinum L.
A. saccharum Marsh.
Alnus rugosa (DuRoi.) Spreng.
Amelanchier canadensis (L.) Med.
Asimina triloba Dunal.

Betula nigra L.
Carpinus caroliniana Walter.
Carya alba (L.) K. Koch.
C. laciniosa (Michx. f.) Loud.
C. ovata (Miller) K. Koch.
Ceanothus americanus L.
Celastrus scandens L.
Celtis occidentalis L.
Cephalanthus occidentalis L.
Cercis canadensis L.
Cornus alternifolia L. f.
C. amomum Miller.
C. asperifolia Michx.
C. florida L.
Diospyros virginiana L.
Dirca palustris L.
*Epigæa repens L.
Evonymus americana L.
E. atropurpureus Jacq.
Fagus grandifolia Ehrh.
Fraxinus americana L.
*F. nigra Marsh.
*Gaultheria procumbens L.
Gaylussacia frondosa (L.) T. & G.
Gleditsia triacanthos L.
Hamamelis virginiana L.
Hydrangea arborescens L.
Ilex opaca Aiton.
Itea virginica L.
Juglans nigra L.
Juniperus virginiana L.
Kalmia latifolia L.
Liquidamber styraciflua L.
Liriodendron tulipifera L.
Lyonia ligustrina (L.) DC.
Magnolia acuminata L.
Morus rubra L.
Nyssa sylvatica Marsh.

Ostrya virginiana (Miller) K. Koch.
Pinus echinata Miller.
Platanus occidentalis L.
Prunus americana Marsh.
P. serotina Ehrh.
Ptelea trifoliata L.
Pyrus augustifolia Ait.
P. arbutifolia (L.) L. f.
Quercus alba L.
Q. marilandica Muench.
Q. muhlenbergii Eng.
Q. prinus L.
Q. rubra L.
Q. stellata Wang.
Q. velutina Lam.
Rhododendron maximum L.
R. nudiflorum (L.) Torr.
R. viscosum (L.) Torr.
Rhus canadensis Marsh.
R. copallina L.
R. glabra L.
R. vernix L.
Rosa carolina L.
R. humilis Marsh.
R. setigera Michx.
Rubus cuneifolius Pursh.
R. hispidus L.
R. villosus Ait.
Salix discolor Muhl.
S. nigra Marsh.
S. tristis Ait.
Sambucus canadensis L.
Sassafras variifolium (Salisb.) Kuntze.
Symphoricarpos orbiculatus Muench.
*Tilia americana L.
*T. michauxii Nutt.
Ulmus fulva Michx.
U. americana L.

Vaccinium corymbosum L.
*V. vacillans Kalm.
Viburnum cassinoides L.
V. dentatum L.
V. prunifolium L.

I B. SOUTHEASTERN NORTH AMERICA (Essentially more characteristic of the Southern states)

Æsculus glabra Willd.
A. pavia L.
Aralia spinosa L.
Bumelia lycioides (L.) Gartner f.
Castanea pumila (L.) Miller.
Celtis occidentalis L. var. crassifolia (Lam.) Gray.
Chionanthus virginica L.
Halesia carolina L.
Leucothoe racemosa (L.) Gray.
Lyonia mariana (L.) D. Don.
*L. ligustrina (L.) DC.
    var. foliosiflora (Michx.) Fernald.
Magnolia macrophylla Michx.
M. tripetala L.
Oxydendrum arboreum (L.) DC.
Prunus hortulana Bailey.
Quercus nigra L.
Rhamnus caroliniana Walter.
Rhus toxicodendron L.
Rosa andrewsianus Blanchard.
Rubus trivialis Michx.
Stewartia malacodendron L.
Tilia heterophylla Vent.
Ulmus alata Michx.
Vaccinium arboreum Marsh.
V. melanocarpum C. Mohr.
Viburnum nudum L.
V. rufidulum Raf.

I C. SOUTHERN APPALACHIAN (Essentially in the mountains and adjacent uplands)

Æsculus octandra Marsh.
A. octandra var. hybrida (DC.) Sarg.
Berberis canadensis Miller.
Calycanthus fertilis Walt.
C. floridus Britt.
Cladrastis lutea (Michx. f.) Koch.
Clethra acuminata Michx.
Cratægus biltmoreana Beadle.
C. phænopyrum (L. f.) Med.
Decumaria barbara L.
Gaylussacia brachycera (Michx.) Gray.
Ilex monticola A. Gray.
I. monticola Gray, var. mollis (Gray) Britt.
*Menziesia pilosa (Michx.) Pers.
Nestronia umbellata Raf.
Philadelphus grandiflorus Willd.
P. inodorus L.
Pinus pungens Lam.
P. virginiana Miller.
Pyrularia pubera Michx.
Rhododendron arborescens (Pursh.) Torr.
R. calendulaceum (Michx.) Torr.
Rhus quercifolia (Michx.) Steudel.
Robinia hispida L.
R. pseudo-acacia L.
Stewartia pentagyna L'Her.

I D. ENDEMIC (Essentially in the Unaka range of eastern Tennessee and western North Carolina, centering in the great Smoky mountains)

Abies fraseri (Pursh.) Poiret.
Andromeda floribunda Pursh.
Buckleya distichophylla (Nutt.) Torr.
Carya, see Hicoria.
*Celtis smallii Beadle.
Cratægus austro-montana Beadle.
C. boyntonii Beadle.

C. buckleyi Beadle.
C. macrosperma Ashe.
C. rubella Beadle.
C. sargentii Beadle.
C. straminea Beadle.
C. vailiæ Britt.
Dendrium prostratum (Loud.) Small.
Diervilla rivularis Gattinger.
*D. sessilifolia Buckley.
Fothergilla gardeni Murray.
Hicoria carolinæ-septentrionalis Ashe.
Hydrangea cinerea Small.
Leucothoe catesbæi (Walter) Gray.
L. recurva (Buckley) Gray.
Magnolia fraseri Walter.
Philadelphus hirsutus Nutt.
Rhododendron catawbiense Michx.
R. punctatum Andrews.
Robinia viscosa Vent.
Spiræa virginiana Britt.
Tsuga caroliniana Engel.
Vaccinium corymbosum L. var. pallidum (Ait.) Gray.
V. erythrocarpum Michx.
V. hirsutum Buckley.

EXTRANEOUS

II A. NORTHEASTERN UNITED STATES (Essentially southern extensions in the Appalachians)

Benzoin æstivale (L.) Nees.
Betula lenta L.
Carya glabra (Mill.) Spach.
C. microcarpa (Nutt.) Britt.
Castanea dentata (Marsh.) Borkh.
Cornus paniculata L'Her.
Corylus americana Walter.
C. rostrata Ait.
Cratægus crus-gali L.
C. punctata Jacq.

C. tomentosa L.
Fraxinus pennsylvanica Marsh.
F. quadrangulata Michx.
Gymnocladus dioica (L.) Koch.
Juglans cinerea L.
Physocarpus opulifolius (L.) Michx.
Pinus rigida Miller.
Prunus alleghaniensis Porter.
Pyrus coronaria L.
P. melanocarpa (Michx.) Willd.
Quercus coccinea Wang.
Q. ilicifolia Wang.
Q. macrocarpa Michx.
Q. palustris Muench.
Q. prinoides Willd.
Ribes rotundifolium Michx.
Rubus alleghaniensis Porter.
R. canadensis L.
R. occidentalis L.
R. odoratus L.
Salix sericea Marsh.
Staphylea trifolia L.
Tsuga canadensis (L.) Carriere.
Ulmus racemosa Thomas.
Vaccinium stamineum L.
Viburnum acerifolium L.
V. alnifolium Marsh.

II B. SOUTHEASTERN CANADA AND NORTHEASTERN UNITED STATES

(Essentially southern extensions in the Appalachians)

Acer pennsylvanicum L.
A. spicatum LaMarck.
Alnus mollis Fernald.
Betula lutea Michx.
Cratægus rotundifolia Borkh.
Gaylussacia baccata (Wang.) K. Koch.
Picea rubra Link.
Pinus strobus L.
Populus grandidentata Michx.

Prunus virginiana L.
Pyrus americana (Marsh) DC.
Rhus typhina L.
Ribes cynosbati L.
R. prostratum L'Her.
Salix humilis Marsh.
Thuja occidentalis L.
Vaccinium pennsylvanicum Lam.

II C. CANADIAN TRANSCONTINENTAL (Of wide northern distribution, with southern extensions in the mountains)

Alnus crispa (Ait.) Pursh.
Cornus stolonifera Michx.
Diervilla lonicera Miller.
Picea mariana (Mill.) B. S. P. (?).
Prunus pennsylvanica L. f.
Rubus idæus L. var. aculeatissimus (Mey.) R. T.
Salix lucida Muhl.
Sambucus racemosa L.
Spiræa salicifolia L.

II D. SOUTHERN (Piedmont, Coastal plain or Mississippian, essentially southern lowland, with northern extension into Tennessee in lowlands)

Catalpa speciosa Warder.
Celtis mississippiensis Bosc.
Nyssa aquatica L.
N. biflora Walt.
Pinus tæda L.
Quercus pagodæfolia (Ell.) Ashe.
Q. phellos L.
Vaccinium virgatum Ait.
V. virgatum Ait. var. tenellum (Ait.) Gray.

II E. SOUTHWESTERN (Here on the northeastern limits of their extension)

Acer leucoderme Small.
Prunus angustifolia Marsh.
Quercus texana Buckley.
Maclura pomifera (Raf.) Schneider.

SUMMARY

Geographic Affinities of the Woody Flora of Mountainous East Tennessee

Geographic Areas	No. Species		Percentages	
I. Intraneous				
A. Eastern North America	89		36	
B. Southeastern North America	27		11	
C. Southern Appalachian	26		10	
D. Endemic	30		12	
Total		172		69
II. Extraneous				
A. Northeastern United States	37		15	
B. Southeastern Canada	17		7	
C. Canadian Transcontinental	9		3.6	
D. Southern, Piedmont, etc.	9		3.6	
E. Southwestern	4		1.6	
Total		76		31
Grand total		248		100

DISCUSSION OF FLORISTIC STATISTICS

There are one or two facts here revealed which are striking. Most conspicuous, I believe, is the small percentage of southern species in the flora, less than 6 per cent. That eastern Tennessee should have so small a number of trees and shrubs characteristic of the southern Piedmont, Gulf strip and Lower Mississippi flora is striking; but when one considers the topography of East Tennessee it seems more proper. The extent and the high altitude of the southern Appalachians (culminating in the Great Smoky mountains) accounts for the relative absence of southern forms because of the actual scarcity of climatic and edaphic situations suitable for such a flora.

Thus viewed it seems quite reasonable that the remaining extraneous species, 25.6 per cent of the total, should be northern in the bulk of their distribution, extending into Tennessee along the very mountains which prevent the southern species from occupying the territory.

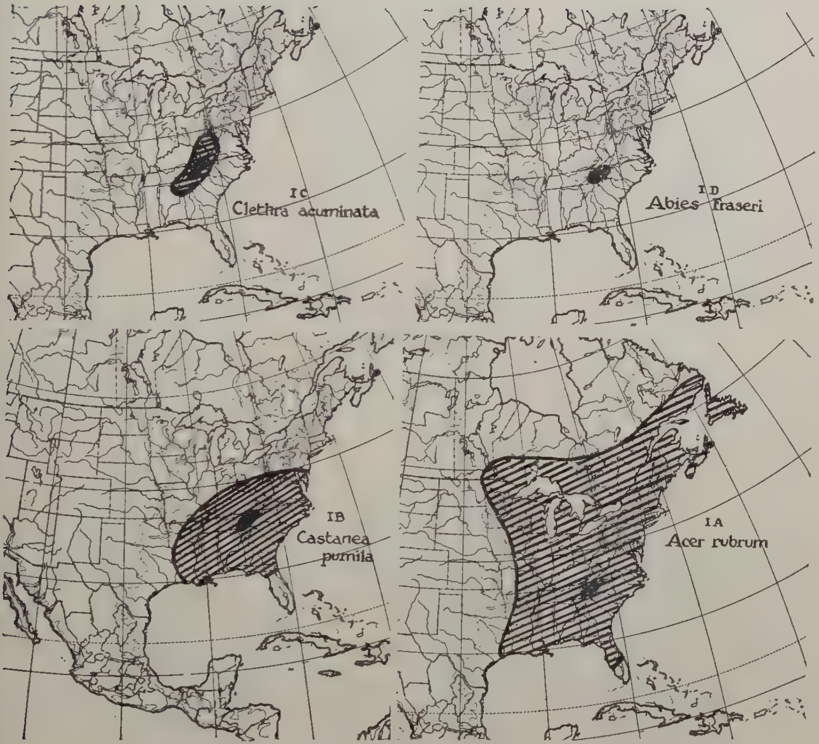
The third point of interest is the relatively high per cent of endemics for a continental region, namely 12 per cent. This high percentage of endemism is explainable on a basis of the extreme age of the territory. Conversely, it is hard to understand why many of the endemic species have not migrated from their restricted area in the mountains and enlarged the extent of their territory. Their local dominance, as in the case of *Abies fraseri, Rhododendron catawbiense, R. punctatum,* etc., is not compatible with an explanation based on lack of aggressiveness, nor is it in agreement with an idea of their recent origin. It is probably due to the restriction of suitable habitat. Adding to the endemic flora those species of somewhat wider distribution, we find almost one-fourth of the trees and shrubs here listed are confined to the southern Appalachians.

Lastly, the presence of extremely northern forms in relatively great abundance is not wholly explained on a basis of the mountain chain offering suitable climatic conditions. It would be possible, of course, for northern forms to have migrated southward along the mountains, occupying the suitable places, although great gaps in the mountains prevent climatic continuity. The reverse is more likely for the majority of the species—the northern species should be viewed as glacial relics. During glaciation, when all vegetation was forced to migrate southward, the southern Appalachians were undoubtedly the great stronghold of northern forms, from which center the northward migration has been continuing since the recession of the ice sheet.

MAPS

The following maps present nine species ranges which can represent the geographic categories used in the present floristic study:

IA. Eastern North America—*Acer rubrum L.*
IB. Southeastern North America—*Castanea pumila (L.) Mill.*
IC. Southern Appalachian—*Clethra acuminata Michx.*
ID. Endemic—*Abies fraseri (Pursh.) Poir.*
IIA. Northeastern United States—*Betula lenta L.*
IIB. Southeastern Canada—*Betula lutea Michx.*
IIC. Canadian Transcontinental—*Prunus pennsylvanica L. f.*
IID. Southern (Piedmont, etc.)—*Celtis mississippiensis Bosc.*
IIE. Southwestern—*Acer leucoderme Small.*



EXPLANATION OF MAPS—PLATE VI

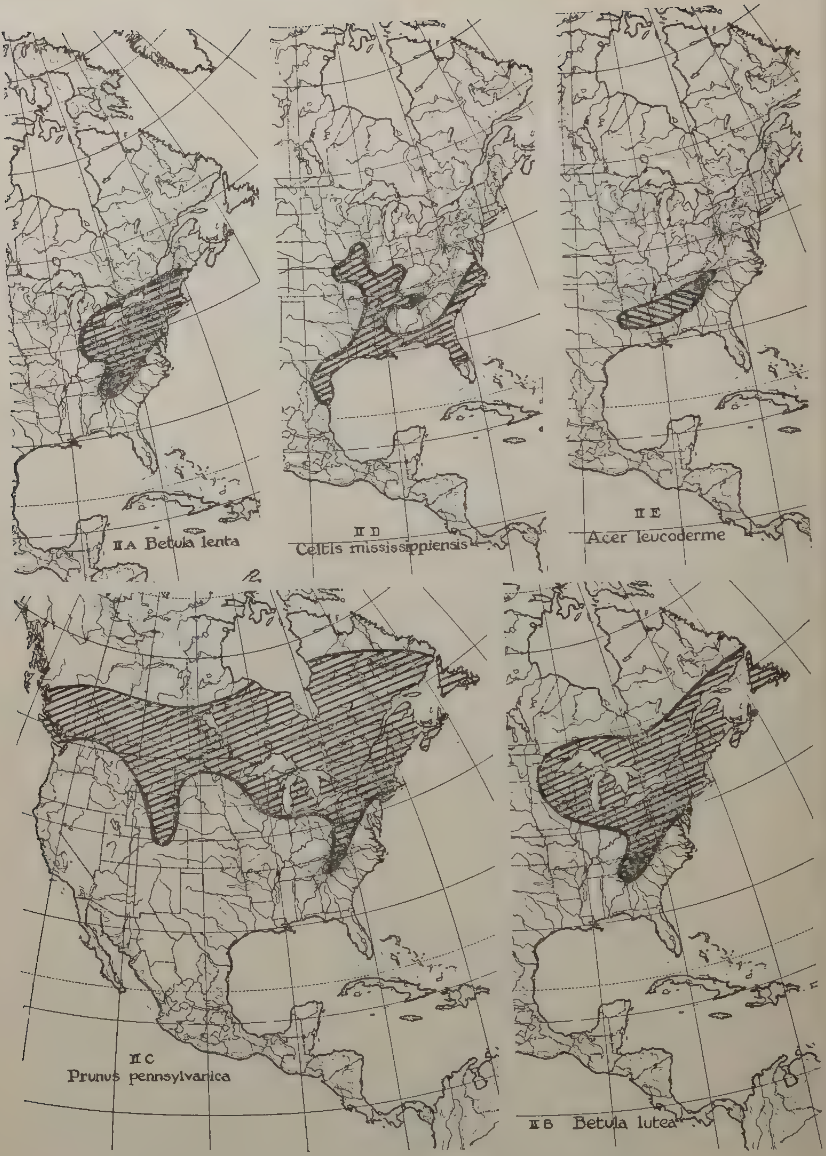
INTRANEOUS DISTRIBUTIONS

Map I A (lower right hand corner)—*Acer rubrum*, representative of eastern North America.

Map I B (lower left hand corner)—*Castanea pumila*, southeastern North America.

Map I C (upper left hand corner)—*Clethra acuminata*, southern Appalachians.

Map I D (upper right hand corner)—*Abies fraseri*, endemic.



EXPLANATION OF MAPS—PLATE VII

EXTRANEOUS DISTRIBUTIONS

Map II A (upper left hand corner)—*Betula lenta,* northeastern United States.

Map II B (lower right hand corner)—*Betula lutea,* southeastern Canada.

Map II C (lower left hand corner)—*Prunus pennsylvanica,* Canadian transcontinental.

Map II D (upper middle)—*Celtis mississippiensis,* southern.

Map II E (upper right hand corner)—*Acer leucoderme,* southwestern.

ORIGIN OF MOUNTAIN ELEMENTS

There are many plants in the mountains of the South which are probably more or less modified descendants of that characteristic flora which in later Miocene time extended to high northern latitudes, also occupying the mountainous region of what is now the north temperate zone. Harshberger lists, from DeSaporta and Marion, a number of species which probably fall in this category:

Danthonia sericea Nutt.
Uniola gracilis Michx.
Poa chapmaniana Schibn.
Arundinaria macrosperma Michx.
Lilium carolinianum Michx.
Cratægus rotundifolia Ehr.
Berchemia volubilis Hill.
Cissus ampelopsis Pers.
Vitis rotundifolia Michx.
Aralia spinosa L.
Arundinaria tecta Walt.
Ulmus alata Michx.
Parnassia grandifolia DC.
Decumaria barbara L.
Itea virginica L.
Cratægus uniflora Muench.
Leucothoe racemosa L.
Oxydendrum arboreum (L.) DC.
Gaylussacia dumosa Andr.
Batodendron arboreum Marsh.

Those in italic are woody species reported, in the present paper, from East Tennessee. Harshberger says of this group of plants: "Most of the species, as well as many of the genera, are characteristic of neither tropic nor northern regions. They belong in great part to groups which are mostly represented at present in the mountainous parts of the warm belt of the north temperate zone, in both eastern and western hemispheres."

It is not within the scope of this paper, but should be mentioned, that this affinity of southeastern United States and western China has been adequately discussed by such famous botanists of the past as Hooker, Gray, Darwin, Sargent, *et al.*

POSITION IN THE SMOKY MOUNTAINS OF PLANTS OF THE VARIOUS AFFINITIES

The spruce-fir forest of the upper slopes, 5,000-6,600 feet in altitude, is definitely northern in its affinities.

Eastern North America
  Amelanchier canadensis (L.) Med.
  Cornus alternifolia L. f.

- Southern Appalachian
  - Ilex monticola A. Gray.
- Endemic
  - Abies fraseri (Pursh.) Poiret.
  - Dendrium prostratum (Loud.) Small.
  - Leucothoe catesbæi (Walter) Gray.
  - Rhododendron catawbiense Michx.
  - R. punctatum Andrews.
  - Vaccinium erythrocarpum Michx. 27%
- Northeastern United States
  - Betula lenta L.
  - Rubus canadensis L.
  - Viburnum alnifolium Marsh. 14%
- Southeastern Canada
  - Acer pennsylvanicum L.
  - A. spicatum LaMarck.
  - Betula lutea Michx.
  - Picea rubra Link.
  - Pyrus americana (Marsh.) DC.
  - Ribes glandulosum Grauer. 27%
- Canadian Transcontinental
  - Diervilla lonicera Mill.
  - Picea mariana (Miller) Britt.
  - Prunus pennsylvanica L. f.
  - Sambucus racemosa L. 18%

Northern total, 59%

While the total woody flora is revealed to contain 26 per cent of northern elements, the spruce-fir forest is found to have a total of 59 per cent of northern elements which find the limits of their southern distribution in the Great Smoky mountains or their vicinity. This massing of northern species is entirely to be expected at the higher altitudes. The so-called northern hardwood forests, mixed, or frequently separated into consociations, as the beech consociation, or the birch consociation, also contain a large per cent of northern elements. At lower altitudes there are increasingly lower per cents of northern elements and increasing higher numbers of widely distributed intraneous species. Kearney (5) has pointed out the southern and coastal plain affinities of certain pine woods of lower altitudes, around 1,200 and 1,500 feet, a correlation which the writer is planning to elaborate in a forthcoming paper dealing with the pine-heath occurring in the vicinity of 3,000 feet and higher on dry southern slopes.

SUMMARY

1. An attempt is made in this paper to view the affinities of the woody species of the Great Smoky mountains on a dual basis. The species are arranged, in the first place, according to their main geographical distributions—whether they are intraneous or extraneous, southern, northern, Canadian transcontinental, etc. Secondly, these geographic classes are considered in respect to their location in the Great Smoky mountains.

2. *Intraneous* species, *i. e.*, those which, in the Smoky mountains, are well within their ranges, constitute 69 per cent of the 248 woody species considered. The remaining 31 per cent of the woody species are to be considered *extraneous*, that is, they are northern or southern extensions or disjuncts into the Smoky mountains and have their main distributions elsewhere.

3. Of particular interest are the following percentages:

a. Twenty-two per cent of the flora is southern Appalachian, while 12 per cent of that group is essentially endemic to the Unaka range, of which the Great Smoky mountains constitute the major portion.

b. Of the extraneous species, 26 per cent are southern extensions of northern species, whereas only 5 per cent are southern; a situation which is clearly related to the mountainous conditions.

4. In the mountains the northern elements appear in increasing importance with increasing altitude until the climax is reached in the spruce-fir zone, with 59 per cent of its woody flora made up of northern species.

I wish to thank Prof. George D. Fuller, of the University of Chicago, and Prof. H. M. Jennison, of the University of Tennessee, for reading the manuscript. The responsibility for errors in the paper rests entirely with the writer. It should be noted that the distributions of species are those described in the manuals. The labor of a more detailed check of distribution is not warranted by the value of the paper.

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BOOK REVIEWS

BIOLOGY

That biology as a unified subject, in contrast to botany and zoology as separate sciences, is continuing to make progress and its advocates are endeavoring to meet the pedagogical needs of teachers of various teaching views, is evidenced by the recent appearance of three new texts within the field. These texts are, Wheat and Fitzpatrick's[1] "Advanced Biology"; Plunkett's[2] "Outlines of Modern Biology," and Scott's[3] "Science of Biology."

The first of these texts is designed for an advanced course in secondary schools. The primary emphasis in the book is placed upon biological principles particularly as they are related to human welfare. Sixteen of the fifty chapters are devoted to human physiology and hygiene, twelve are devoted to bacteria and disease, and thirteen to reproduction, heredity and evolution. The authors have succeeded in presenting their material in such a clear and interesting manner and yet have handled such difficult (for secondary schools) materials as chromosome mechanism of heredity, Mendelian behavior, mutations, etc., that one could well wish that every boy and girl might use it as a guide toward a real appreciation of biology and a proper understanding of the laws of reproduction. The book ends with several valuable appendices. It is to be regretted that the table on foods does not contain information on vitamins in addition to the other information presented.

The second of these texts is a college book which has as its central concept the living organism as a physicochemical mechanism. Treatment of subject matter represents a complete departure from the usual phylogenetic or taxonomic order of consideration.

The nature of the physiological principles themselves determines the order of consideration, rather than degree of complexity of structure of organisms presenting them. One chapter each is devoted to reproduction of the entire range of multicellular plants and multicellular animals, so that the student will hardly develop an "organism-as-a-whole" concept.

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[1] WHEAT, FRANK M., and ELIZABETH T. FITZPATRICK. Advanced biology. pp. viii + 567. New York: American Book Co. 1930.

[2] PLUNKETT, C. R. Outlines of modern biology. pp. vii + 711. figs. 198. New York: Henry Holt & Co. 1930.

[3] SCOTT, GEORGE H. The science of biology. pp. xx + 633. figs. 389. New York: Thomas Y. Crowell Co. 1930.

The chapters dealing with heredity, development and evolution are very well done and go far toward developing the conception of plant and animal physiology as a unity and thus justifying biology as a science. The problems involved in reaching definite conclusions regarding the origin of life are presented in a very admirable manner in the closing chapter.

The third of these texts presents the material primarily in three sections. The first section deals with the biology of plants and the second with that of animals. In each of these sections morphology and reproduction are considered first and types are chosen representing the entire phylogenetic range in each kingdom. Following the morphological treatment, the physiology of plants and animals is considered in their respective sections.

Section three deals with general biology and, after a treatment of the morphology and physiology of the cell, chapters on embryology, histology, comparative anatomy, reproduction, physiology of organisms as a whole, genetics and evolution follow, with a final chapter on the biology of man. This text will make its appeal to teachers who prefer a phylogenetic consideration as the framework upon which all other principles may be built.

EDUCATIONAL BIOLOGY

That educationists have recognized the value of biology as fundamental in laying the foundation and creating the proper perspective in the preparation of teachers, is indicated by the appearance of two excellent texts in this field, *viz.*, Eikenberry and Waldron's[4] "Educational Biology" and Atwood and Heiss'[5] "Educational Biology." These books are written primarily for students in their first year of college or normal school training for the teaching profession, but both contain such a wealth of biological information, so interestingly said, that they are well worth consideration by all who wish to know something of the spirit and contribution of modern biology to present-day civilization in general and the handling of educational, sociological and hygienic problems in particular.

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[4] Eikenberry, W. L., and R. A. Waldron. Educational biology. pp. vii + 549. figs. 236. Boston: Ginn & Co. 1930.

[5] Atwood, William H., and Elwood D. Heiss. Educational biology. pp. xii + 469. figs. 259. Philadelphia: P. Blakiston's Son & Co. 1928.

The latter text will probably make its appeal more to the teacher who is first a biologist and second an educationist, while the former will probably do the reverse. By this is meant: the latter follows the type method of presenting material which in the very nature of the case lends itself to a greater degree of biologically logical continuity from chapter to chapter, while in the former principles and life processes form the ground plan of organization and the material is therefore more physiological than anatomical, and hence, in the very nature of the case, the concept of organisms as a whole, and consequently phylogenetic continuity, are lacking.

But when one notes the purposes for which the books were written, *viz.*, to create biological atmosphere and viewpoint in educational work and not to prepare students for advanced biology, we must say that the authors have done their work well, even though very different methods are employed.

COLLEGE TEXTBOOK OF BOTANY

Mottier's College Textbook of Botany for First Year Students[6] is unique in several ways. It has probably the best account of diatoms, red algæ, brown algæ and the liverwort Anthoceros that can be found in any general botany text written in the English language. However, there is practically no information on such topics as heredity, evolution, the nature and method of plant classification, the relation of botany to other sciences, and ecology. Students and teachers can find in it useful information and illustrations which are not to be found in other general texts. For example, the following points are considered in more than usual detail: Cell division in Œdogonium, probable function of pycniospores in *Puccinia graminis*, methods of cell formation in plants, colloidal character of protoplasm, function and position of scales in the gametophyte of Marchantia. The chapters on the cell, the leaf, the root and the stem do not bring out any relationship between structure and function, while the chapters on the plant groups are lacking in diagrams of life cycles. Mottier's book is an excellent reference text, and for many colleges it may represent the most suitable one for regular classroom work.

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[6] MOTTIER, D. M. A college textbook of botany for first year students. pp. xvii + 516. figs. 333. Philadelphia: P. Blakiston's Son & Co. 1929.

GREEN MAGIC

Julia Closson Kenley[7] in "Green Magic" brings to the plane of the child in a most interesting style the fundamentals of plant habits, structures and behavior. Seeds, leaves, stems, roots and flowers, with their parts and functions, are well discussed, together with many variations occurring in these organs. The subject of protoplasm is well presented, such as to impress any child with the fact that it is the basic substance of all life. The book will meet a very distinct need in its attempt to awaken and develop the powers of observation and stimulate in children an interest in nature.

NATURISTS

"American Naturists," by Henry Chester Tracy,[8] is a collection of semi-biographical sketches of twenty-one well-known nature writers. The appeal is made to us to recognize the unique character of our own American nature literature.

The author distinguishes as "naturists" those who feel and enjoy nature and write of it from the standpoint of literature and philosophy of life, in contrast to "naturalists," who write of it in terms of pure science. This distinction seems unnecessary, but is doubtless due to the author's thinly veiled feeling against pure science.

The book will be interesting to the scientist because of the history it reveals in the development of natural science and the debt science owes to these early students and lovers of the great out-of-doors.

PLANT PHYSIOLOGY

All students of plant physiology, both teachers and research workers, will welcome Barton-Wright's[9] "Recent Advances in Plant Physiology." This volume will be of immense value to the instructor attempting to keep his lecture notes up to date, because the material is very well organized and logically arranged in nearly the same order which the average instructor would use for the classroom presentation of his lectures. It will be of equal value to the advanced student and research worker, because it gives orientation to the mass of physiological material published during the period 1918 to 1928 which it is intended to cover.

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[7] KENLEY, JULIA CLOSSON. Green magic. pp. xii + 184. figs. 57. New York: D. Appleton & Co. 1930.

[8] TRACY, HENRY CHESTER. American naturists. pp. viii + 282. New York: E. P. Dutton. 1930.

[9] BARTON-WRIGHT, E. C. Recent advances in plant physiology. pp. xii + 352. figs. 51. Philadelphia: P. Blakiston's Son & Co. 1930.

The opening chapter considers soil and water relations; and transpiration, photosynthesis, nitrogen metabolism and respiration follow in the order named. The volume closes with a consideration of the physiology of growth, which includes germination and dormancy, concerning which considerable literature has appeared during the past decade. It also organizes the work in mineral relations, light relations, temperature and other factor relations.

While no two physiologists would select entirely the same material for such a volume, it does seem that the new researches on periodicity of mitotic behavior, a number of which have appeared during the period covered by the volume, should have been given a place. However, the volume will be of much service to all students in this field of botany.

THE PROTEASES OF PLANTS

Vines[10], finding his published accounts of experiments on proteolytic enzymes criticized, reviews his own work. He defends his former conclusion that there are two distinct enzymes in protein decomposition, one which digests proteins and the other which digests proteoses. Two points seem to be stressed in the pamphlet, first, that there are two distinct enzymes, and second, that the author should be given credit for his pioneer work in the field.

ROCK GARDENS

All who love flowers, and particularly the rock garden, will welcome Henry Correvon's[11] latest contribution, "Rock Gardens and Alpine Plants." This is not a translation of a previous volume, but an entirely new work written in English and specifically for American plant lovers. Garden lovers need no introduction to M. Correvon, and his volume will be of special interest not only to the amateur and professional, but also to the botanist, horticulturist and field worker as well.

He lists alphabetically the names and discusses the uses of ferns, orchids, hardy cacti and other plants for the rockery, wall or alpine garden. The volume constitutes a very real contribution to floriculture and fills a long felt need in America.

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[10] Vines, S. H. The proteases of plants, a record and a reply. pp. 32. London: Macmillan & Co 1930.

[11] Correvon, Henry. Rock garden and alpine plants. pp. xv + 544. pls. 16 (8 colored). New York: The Macmillan Co. 1930.

ROSES

Those who are interested in roses will welcome McFarland's[12] "Modern Roses." This volume will be of immense service to every grower, dealer and breeder of roses, as well as to those who love them on their table as cut flowers. It contains 2,511 variety descriptions, with forty-eight color and thirty-one sepia plates. This is a monumental work in rose pedigrees, and a very great debt is owed its author for his enormous labors in compiling it. Every variety is described in uniform terms, including its type, originator, parentage, date of origin and a description sufficient to identify it from others, as well as notes on hardiness, culture, susceptibility to disease, vigor of growth and season of flowering. In the appendix is given a long alphabetical list of rose originators and introducers.

TAXONOMY

The student and teacher of taxonomy will welcome Pool's[13] new contribution to the field of systematic botany. This comes in the form of a textbook for courses in plant classification. The material is logically arranged and very well organized. The first eight chapters deal with the necessary foundation material by way of the structure and behavior of flowers, fruits and seeds, and types of inflorescence. In this consideration floral diagrams are explained and their value emphasized, and there is added a very ingenious, interesting and convenient system of formulæ or, as it were, shorthand descriptions of families. Later in the volume this is used as a "short cut" key to families. This scheme of family formulæ and their use for diagnostic purposes represents a new and interesting departure in plant identification.

Four chapters are devoted to history and principles of classification and twelve chapters to a consideration of selected orders and families.

A valuable feature of the book is the very extensive list of references to taxonomic literature given in the final chapter. The book is not only well written from the author's standpoint, but the printing and figures are also very well done.

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[12] McFarland, J. Horace. Modern roses. A uniform descriptive list of all important roses in commerce. pp. viii + 284. pls. 39. New York: The Macmillan Co. 1930.

[13] Pool, R. J. Flowers and flowering plants. An introduction to the nature and work of flowers and the classification of flowering plants. pp. xx + 378. figs. 191. New York: McGraw-Hill Book Co. 1929.